GEOCHEMISTRY OF LARGE COSMIC SPHERULES AND MICROMETEORITES FROM NORTHERN GREENLAND.

Engrand C.*, Kurat G.*, Awoke, H.-M.**, Koeberl C.**, Hammer, C***., and Maurette M****; (*) Naturhistorisches Museum, Postfach 417, A-1014 Vienna, Austria; (**) Institut fuer Geochemie, Universitaet Wien, A-1090 Vienna, Austria; (***) Department of Geophysics, University of Copenhagen, DK-2100 Copenhagen, Denmark, (****) C.S.N.S.M., Bat. 104, F-91405 Campus Orsay, France.

Introduction. The collection of cosmic spherules (CSs) from any location on the Earth should provide a good average of the extraterrestrial influx on Earth. In addition, it should also contain a good sample of meteoroids of a mass range and/or entry velocity range, which precludes atmospheric entry without melting, e. g., minimeteoroids (mm size range) and non-asteroidal samples. There is a distinct difference in chemical and mineralogical composition between interplanetary dust of different sizes, e. g., between micrometeorites (MMs, the main influx mass, about 200 µm in diameter [1,2]), stratospheric interplanetary dust particles (SIDPs, about 10 µm in diameter [3]), and meteorites and their constituents (> 1 mm [4]). Thus, we can surmise that minimeteorites should represent the compositional transition between micrometeorites and meteorites (and their constituents, like chondrules). The large collections of cosmic dust from Greenland [5-7] and Antarctica [8,9] contain some candidates but the total sample of possible OC-like matter is still very small [10]and that of possible achondritic or of lunar origin is still non-existing.Therefore, we continue our search for those components. A new collection from Northern Greenland was aquired with the specific goal to properly preserve the size fraction > 0.5 mm.

Samples and methods. Samples of glacial sediments were collected during the Hans Tausen field expedition in August 1995 to Northern Greenland on the margin of the Greenland ice sheet at a latitude of 82 °. In particular, samples of cryoconite were collected at various locations on the ice, and subsequently disaggregated in the laboratory on sieves of varying mesh sizes. From these sediments, CSs and MMs were hand-picked under the microscope. A collection of 98 CSs and particles was extracted from 100 g of glacial sediment of the size fraction >100 µm. For the first instrumental neutron activation analysis (INAA) charge we selected five CSs (mostly large) and five MMs (the largest ones). The particles were studied by optical microscopy and analytical scanning electron microscopy (ASEM) and subsequently analyzed by INAA following standard procedures. After gamma-counting the samples were mounted in epoxy, polished, and investigated by optical microscopy and ASEM.

Results. Petrographic characteristica are given in the Table. CI-normalized abundances of selected trace elements are shown in Figs. 1 and 2. The spherules are enriched in the refractory elements as compared to CI chondrites and depleted in Na, K, and Zn, but not in Rb. Three of the five CSs are enriched in the LREEs relative to Sc, and one is depleted in Sc (Gr1-38) with respect to the others. The CS richest in REEs is also rich in K and Br. The siderophile element abundances show three types of patterns for the refractory and moderately volatile elements: 1, strong depletion in Ir and Ni, and increasing relative abundances of Co and Fe; 2, strong depletion in Ir with almost unfractionated relative abundances of Ni, Co, and Fe; 3, chondritic abundances of Ir, Ni, Co, and Fe. The volatile siderophile elements have similar abundance pattern in all CSs (at different abundance levels) for Fe (undepleted with respect to Cis), Au (depleted), Sb (enriched), and Se (depleted).

The MMs are richer in trace elements as compared to the SCs and are less depleted in the moderately volatile elements. Three of the MMs are strongly enriched in the REEs, displaying an LREE-enriched pattern with a small negative Eu anomaly. These are also enriched in Br as compared to the others and to CI. The siderophile element abundances are highly diverse and have only in common a strong depletion in the Se and a strong enrichment in the Sb content relative to CI chondrites. One small particle (Gr1-80) is strongly depleted in Ir, Ni, Co, and Au (about 0.01 x CI) with chondritic relative abundances of these elements. Two are moderately depleted in Ir and Ni with one of them (Gr1-83) having unfractionated Ir, Ni, Co, Fe, and Au abundances. Two MMs are enriched in Ir as compared to CI with Ir/Ni < CI.

Discussion. Our CSs have elemental abundances very similar to many others investigated before [5,6,8,10]. They clearly represent extraterretrial samples, which, however, have been chemically altered by a variety of processes. The most obvious alteration is clearly due to evaporative loss of volatile elements during the melting event in the atmosphere (Na, K, Zn, Au, Se). Another process is the separation and loss of a metal melt from the silicate melt leading to depletions in Ir, Au, and Ni. The largest CS shows evidence for such a fractionation process. During exposure to the terrestrial environment, CSs also become contaminated by elements which are enriched in the Earth's crust compared to chondrites. This contamination, specific to cryoconite in Greenland, is related to pore space and Fe oxides/hydroxides [5], the effects of which, however, are just decernible in the porous CSs Gr1-6 and Gr1-35 (Fig. 1). Only one CS, Gr1-38, has a siderophile element abundance pattern that is compatible with a chondritic aggregate or a chondrule as a precursor [11]. Particle Gr1-70 is very peculiar - a pseudo-spherule consisting of a BO-textured, magnetite-rich core, surrounded by carbonaceous matter which we could not characterize so far (tar?). Its trace element content is chondritic, inclusive the siderophile elements, similar to some descibed by [5]. It could represent an ablation melt from a carbonaceous chondrite, as indicated by the depletion in Ni compared to the other siderophile elements [12].

As a result of the destruction of the most friable MMs during the disaggregation of cryoconite the unmelted MMs are mainly of the crystalline type [compare 2,5]. Three of them are fairly porous and, therefore, are likely to be contaminated by terrestrial lithophile elements, similar to what has been found before [5]. However, the mineralogy and the siderophile element abundances appear to be pristine and are compatible with those of chondrules [11, 13]. Particle Gr1-80 is rich in Na and K, without being rich in REEs, contains FeO-bearing olivine, albitic felspar, and Fe sulfide, and is very poor in siderophile elements - features which are compatible with an OC chondrule precursor. This particle could, therefore, be another member of the rare possibly OC-derived MMs [14], which comprise about 1% (by number) of the total MM population, whereas all others seem to be related to CC chondrules or aggregates [11].

Thus, in spite of being highly biased in favor of the least friable particles, the Northern Greenland cosmic dust collection is an important extension of the existing collections in space, time, and rare particle population.

Acknowledgements. This work was supported by FWF in Austria and IN2P3 in France.

References. [1] Love S.G. and Brownlee D.E. (1993) Science **262**, 550; [2] Kurat G. et al. (1994) GCA **58**, 3879-3904; [3] Brownlee D.E. (1985) Ann. Rev. Earth Planet. Sci. **13**, 147; [4] Wasson J.T. (1985) Meteorites. Freeman; [5] Robin E. (1988) Thesis Universite de Paris-Sud, 131pp; [6] Maurette M. et al. (1987) Nature **328**, 699-702; [7] Christophe Michel-Levy M. and Bourot-Denise M. (1992) Meteoritics **27**, 73-80; [8] Maurette M. et al. (1991) Nature **351**, 44-47; [9] Walter J. et al. (1995) LPSC XXVI, 1457-1458;[10] Presper T. (1993) Thesis Universitaet Mainz, 120pp; [11] Kurat G. et al. (1985) LPSC XVI, 471-472; [12] Presper T. et al. (1993) LPSC XXIV, 1177-1178; [13] Rubin A.E. and Wasson J.T. (1988) GCA **52**, 425; [14] Walter J. et al. (1995) Meteoritics **30**, 592-593.

Table: Petrographic characteristics of Greenland Gr1-95 samples.

Particle	Type	Mass	Texture	Features
Gr1-6	CS	36.3	hyaline, few bubbles	very low Ir, Ni, Se
Gr1-15	CS	41.4	fine-grained BO	very low Ir, Ni, Se
Gr1-35	CS	8.3	porous PO	rich in REE and K
Gr1-38	CS	7	PO, porous surface	very low Ir, high Ni, Co
Gr1 -70	Ps-CS	55.2	silic.core, carbon. mantle	high Ir, Ni, Co
Gr1 -71	MM	19.8	crystall., fo,en, ox, porous	REE-, Br-, Ir-, Sb-rich
Gr1-72	MM	22.4	hyaline, foamy	REE-,K-, Ir- Ni-rich
Gr1-73	MM	78.6	crystall., fo, ox., sulf., met .	REE-, Ir-, Co-, Sb-rich
Gr1-80	MM	6.8	porph. ol, gl., alb., sulf.	chon. REE +Na+K, low Ir
Gr1-83	MM	11.2	en, porous surface	chon. REE, non-fract. sid.

Figures:

Figure 1: CI-normalized elemental abundances in cosmic spherules from Greenland.

Figure 2: CI-normalized elemental abundances in micrometeorites from Greenland.

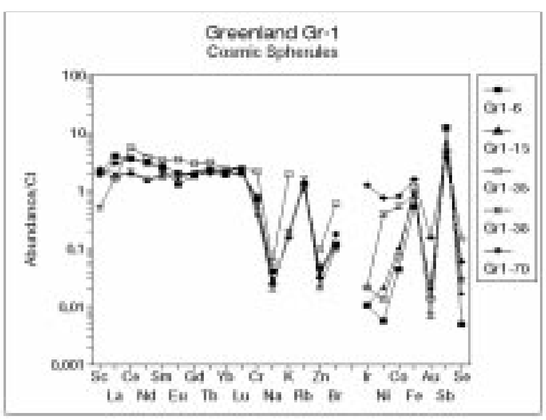

Fig. 1

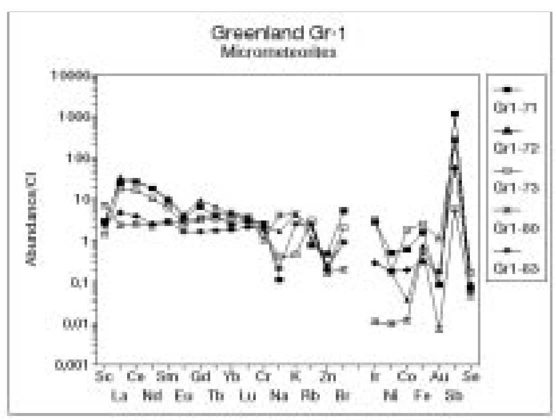

Fig. 2